

CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-148

Southern Foothills Fault System,  
Amador, Calaveras, El Dorado, and Tuolumne Counties

by

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1. Name of faults

Rescue, Youngs Creek, Negro Jack Point, and Bowie Flat segments of the Bear Mountain fault zone and Poorman Gulch, Rawhide Flat East, and Rawhide Flat West segments of the Melones fault zone.

2. Location of faults

Coloma, Melones Dam, Mokelumne Hill, Keystone, Sonora, and Valley Springs 7.5-minute quadrangles, El Dorado, Amador, Calaveras, and Tuolumne Counties (figure 1).

3. Reason for evaluation

Part of 10-year fault evaluation program (Hart, 1980).

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#### 5. Review of Available Data, Field Observations, and Air Photo Interpretation

The Foothills fault system in the western Sierra Nevada, first named by Clark (1960), was not considered to be recently active prior to the 1975 M5.7 Oroville earthquake. Surface fault rupture along the Cleveland Hill fault zone was associated with the Oroville earthquake, and, subsequently, was zoned for Special Studies on January 1, 1977 (CDMG, 1977). As a result of the Oroville earthquake, geotechnical investigations for the proposed Auburn Dam were greatly expanded. Woodward-Clyde Consultants (WCC), under contract for the U.S. Bureau of Reclamation (USBR), conducted detailed studies of the Auburn damsite, but also investigated earthquake hazards elsewhere in the western foothills of the Sierra Nevada (Alt, et al., 1977; Schwartz, et al., 1977). WCC also investigated the southern Foothills fault zone for Pacific Gas and Electric (WCC, 1978). Thus, significant new data on recently active faults in the foothills were developed. Selected segments of the Foothills fault system from Sonora north to near Oroville are evaluated in three Fault Evaluation Reports (FER), two of which have been prepared (Bryant, 1983a and 1983b). This third FER evaluates selected faults in the area from Sonora north to near Folsom Lake. Individual faults evaluated include the Bowie Flat, Poorman Gulch, Negro Jack Point, Rawhide Flat East and West, Youngs Creek, and Rescue faults (figures 1 and 3).

The Foothills fault system consists of the Melones fault zone on the east and the Bear Mountain fault zone on the west (Clark, 1960, 1964, 1976; Cebull, 1972, Duffield and Sharp, 1975). Faults within the FER study area include segments of both the Bear Mountain and Melones fault zones. The Foothills fault system was generated by eastward plate convergence and subduction during early Mesozoic time (Hamilton, 1969; Schweickert and Cowan, 1975; Clark, 1976). This episodic period of plate convergence produced the dominant structural features in the western Sierran foothills and the Foothills fault system. In general, structural elements that comprise the Foothills fault system are subparallel to regional foliation and cleavage. This has resulted in a strong structural grain dominated by planar elements that strike north-northwest and generally dip steeply east.

Superimposed on this compressional structural fabric is a late-Tertiary to present period of east-west extension (Alt, et al., 1977). This east-west extension has resulted in high-angle normal faults that occur along pre-existing Paleozoic and Mesozoic structures (Alt, et al., 1977). However, Alt, et al. found evidence indicating that late-Cenozoic activity has not occurred along all pre-existing faults of the Foothills fault system.

Rock types in the FER study area consist predominantly of Late Jurassic metavolcanic and metasedimentary rocks, Paleozoic metasedimentary rocks, serpentine, and isolated, sinuous outcrops of Miocene-Pliocene Mehrten Formation, including Table Mountain Latite (Wagner, et al., 1981; Rogers, 1966; Alt, et al., 1977; WCC, 1978). A characteristic problem with evaluating recent fault activity in the western Sierran foothills is the general lack of Tertiary and Quaternary material overlying much of the Mesozoic bedrock.

Remnants of a paleo-B soil horizon developed on Mesozoic bedrock locally occur in the western Sierran foothills. This paleosol is thought by WCC to have formed about 100,000 years B.P. (Swan and Hanson, 1977). However, the U.S. Geological Survey (1978) and Borchardt, et al. (1980) suggest that the foothills paleosol was actively developing from about 140,000 years to 10,000 years B.P. They reason that the paleosol probably began to form about 100,000 years to 140,000 years ago and continued to develop until eroded or deeply buried by younger deposits. Therefore, its age extends to the age of the overlying erosion surface or deposits. In many places, the overlying deposit is what Borchardt, et al. termed the foothills colluvium, a relatively unweathered colluvium thought to have formed about 9,000 years B.P. (Swan and Hanson, 1977; Borchardt, et al., 1980).

Land surfaces in the FER study area generally have not been modified by grading. Topography in the study area is characterized by linear ridges and valleys reflecting differential erosion along the strong northwest-trending Mesozoic structural fabric. Massive landsliding in the area generally is not widespread, but local soil creep and expansive soils have affected or modified soil-bedrock relationships.

Extremely low slip-rates of about 0.005mm/yr (Bryant, 1983a, 1983b; Schwartz, et al., 1977) are characteristic of individual potentially active faults in the western Sierran foothills between Oroville and Auburn. These faults were evaluated in FER-146 and 147 (Bryant, 1983a, 1983b), and it was concluded that they did not meet the zoning criteria of sufficiently active and well-defined (Hart, 1980). Based on the results of these FER's and limited time constraints, this FER is limited to a literature survey and very brief air photo interpretation of selected fault segments. Table 1 summarizes results of geological investigations by WCC (1978) along selected segments of the Bear Mountain and Melones fault zones. Only those faults having reported evidence of Quaternary offset were evaluated in this FER. Additional Quaternary-active faults may be present along the Bear Mountain and Melones fault zones, but no attempt was made to identify them in this FER.

#### BEAR MOUNTAIN FAULT ZONE

Fault segments within the Bear Mountain fault zone to be evaluated in this FER include the Rescue lineament, Youngs Creek, Negro Jack Point, and Bowie Flat faults (figures 2 and 3).

##### Rescue Lineament

The Rescue lineament is a northwest-trending feature that generally corresponds to a fault separating Jurassic metavolcanic rocks on the west from serpentine and metavolcanic rocks on the east (Wagner, et al., 1981) (figure 4). Two sites along the Rescue lineament were investigated by WCC; the Luneman Road and Knolls exploration sites (Schwartz, et al., 1977).

The Rescue lineament at the Luneman Road site is expressed as a well-defined vegetation contrast within a linear valley (Schwartz, et al., 1977). Three trenches were excavated across this vegetation contrast (figure 4). Trenches 1 and 2 did not expose evidence of Quaternary faulting. Trench 2 exposed a remnant paleo-B soil horizon that does not seem to be offset. Trench 3 exposed an east-dipping normal fault that seems to displace a remnant paleo-B soil horizon. WCC (Schwartz, et al., 1977) mapped a shear extending into overlying younger colluvium. This shear is probably related to downhill creep because: 1) the fault plane deflects downslope as if under the influence of gravity, 2) the shear in colluvium does not visibly displace the bedrock-colluvium contact, and 3) evidence of downslope creep is common within

this trench exposure. If Holocene activity has occurred along this fault, one would expect to see an east-facing scarp associated with the fault. No evidence of a scarp was observed, based on the topography shown on the trench log and the photographs shown in figure A-13 of Schwartz, et al. (1977).

The Knolls exploration site is located south of the Luneman Road site. The Rescue lineament here is characterized by a more southerly trending zone delineated by a linear valley. Four linear tonal contrasts within this linear valley presumably indicate recently active traces of the Rescue lineament. One trench was excavated at the Knolls site by WCC (Schwartz, et al., 1977) (figure 4). An east-dipping fault with an apparent reverse sense of displacement (west side down) was observed. A remnant paleo-B soil horizon is apparently offset about one foot or less, down to the west. However, shears were not observed in the paleosol. A down-to-the-west step in the bedrock-paleosol and paleosol-colluvium contacts was observed, but there is no clear evidence of faulting. Borchardt, et al. (1980) postulate that most of the remnant paleosols exposed in this trench are "soil tongues" developed along old fault planes.

Borchardt, et al. (1980) differ with WCC in their interpretation of the paleosol configuration west of the fault. Borchardt, et al. map an approximately 10cm gain in elevation of the paleosol, and indicate that this configuration is compatible with a relatively thick "soil tongue" developed along an old shear. Subsequent erosion of the paleosol and deposition of colluvium has given the appearance of an offset paleosol. Depth functions for Ca/Fe ratios of paleosol remnants on either side of the fault support in situ soil formation within two slightly different bedrock types, rather than displacement due to faulting (Borchardt, et al., 1980).

Geomorphic evidence of Holocene normal or reverse faulting was not observed along the Rescue lineament by this writer, based on a brief field check of the Luneman Road and Knolls sites.

#### Youngs Creek Fault

The Youngs Creek fault is associated with a northwest-trending Mesozoic bedrock structure. Cenozoic deformation along the Youngs Creek fault is expressed as down-to-the-east normal faulting (Alt, et al., 1977; P.G. and E., 1978). The Miocene-Pliocene Mehrten Formation is offset along the Youngs Creek fault about 18 feet, down to the east (Alt, et al., 1977). Three trenches were excavated across the Youngs Creek fault (figure 5). Trench 1 exposed a N27°W-trending, 60°E-dipping fault that offsets rocks of the Mehrten Formation, but not the overlying paleo-B soil remnant. Trench 2 exposed a steeply east-dipping fault in Mehrten Formation. Overlying colluvium was not offset by the fault. Trench 3 exposed an east-dipping shear in Mehrten Formation. Young colluvium (Holocene?) is not offset along this fault. A remnant paleo-B soil horizon occurs west of the fault, but is not present to the east of the fault. No shears are present within or near the eastern margin of the paleosol. If post-paleosol normal faulting (down to the east) has occurred, then significant downhill creep has distorted original geometric relationships. The preservation of a buried paleosol west of a down-to-the-east normal fault and a westward-sloping ground surface argue against Holocene normal faulting. It is possible that a right-lateral strike-slip component of displacement has occurred along this fault. This may explain the absence of the paleosol on the east side of the trench. Thus, a post-paleosol displacement may have occurred, but evidence for Holocene displacement (i.e. displaced colluvium) is lacking.

WCC (1978) concluded that late Quaternary deposits exposed at the Youngs Creek site were not sufficient to adequately evaluate the capability of the Youngs Creek fault. However, surficial deposits were not offset and the paleosol was too sparse for any definite conclusions regarding displacement along the Youngs Creek fault.

#### Negro Jack Point Fault Zone

The Negro Jack Point fault zone consists of northwest-trending normal faults that generally have down-to-the-east displacement (WCC, 1978). Scarps offsetting the surface of the Table Mountain Latite surface range in height from 8 to 30 feet (east side down) (Alt, et al., 1979).

A total of eight trenches were excavated across segments of the Negro Jack Point fault zone (figure 6). Results of these exploration trenches are listed in table 1. Trench 1 exposed a north-trending, 60°W dipping fault that extends into a remnant paleo-B soil horizon. However, the base of the paleosol is not visibly offset, and there is no evidence of shearing or displacement of younger colluvium. The east-facing break in slope above the fault isn't compatible with the sense of offset of Tertiary bedrock observed in the trench. There is no evidence of Holocene-age faulting in Trench 3. Fractures in older alluvium east of the principal fault zone may represent a minor, down-to-the-west fault zone, but overlying younger colluvium is not offset. An apparent erosional step in the principal fault plane suggests that faulting has not occurred since deposition of the S2 colluvium. Trenches 4 and 5A,B,C do not have evidence of Holocene faulting. Minor shears and displacement of an older alluvial channel observed in Trench 6 are not continuous and do not displace Holocene (?) colluvium.

Geomorphic features associated with the Negro Jack Point fault zone generally consist of discontinuous fault scarps on the Table Mountain Latite surface. Evidence of recent faulting along the Negro Jack Point fault in units younger than the Table Mountain Latite was not observed by this writer. Ephemeral geomorphic features indicative of recent faulting, such as closed depressions and vertically offset drainages, were not observed by this writer along traces of the Negro Jack Point fault zone, based on interpretation of U.S.G.S. air photos (GS-VYU, 1959) (figure 6).

#### Bowie Flat Fault

The Bowie Flat fault is a northwest-trending Cenozoic fault that generally correlates with a Mesozoic shear zone (WCC, 1978). Displacements of the Miocene Table Mountain Latite surface range from 20 feet to about 50 feet, down to the east. WCC excavated seven trenches across traces of the Bowie Flat fault (Table 1) (figure 6).

Trenches 1 and 2 exposed evidence of Quaternary-active normal faulting. In Trench 1, the principal fault is delineated by a N30°W-trending 83°E-dipping fault. A paleosol is displaced across the fault in a monoclinical warp, with about 1 foot of vertical separation, down to the east. No shear planes occur in the paleosol, and younger colluvium overlying the paleosol is not offset.

Trench 2, located about 100 feet northwest of Trench 1, exposed a fault striking N43° to 53°W and dipping 72°-77°NE. A discontinuous remnant of a paleo-B soil horizon is vertically displaced across the fault about 0.8 foot, down to the east. Shears extend up into cemented alluvium, but the alluvium-colluvium contact is not offset. There is no scarp associated with this fault, and the uppermost soil is not displaced nor does it thicken across the fault. Thus, Holocene activity is not indicated.

Trenches 3, 4A, 4B, 6, and 7 did not expose evidence of Quaternary faulting. Trench 7 exposed a relatively continuous paleosol that was not offset.

Well-defined geomorphic evidence of Holocene-active faulting along the Bowie Flat fault was not observed by this writer, based on very brief air photo interpretation (U.S.G.S. GS-VYU, 1959) (figure 6).

#### MELONES FAULT ZONE

Fault segments within the Melones fault zone evaluated in this FER include the Poorman Gulch, Rawhide Flat East, and Rawhide Flat West fault zones (figure 3).

#### Poorman Gulch Fault

The Poorman Gulch fault is a major Mesozoic structure that juxtaposes rocks of the Jurassic Mariposa Formation on the west against rocks of the Paleozoic Calaveras Complex (Alt, et al., 1977; Wagner, et al., 1981). The total cumulative vertical displacement across the base of the Miocene-Pliocene Mehrten Formation is about 90 feet, down to the east (Alt, et al., 1977).

WCC (1978) excavated three trenches across the Poorman Gulch fault (Table 1, figure 7). Fault-colluvium relationships in Trench 1 are obscured by landsliding, but evidence of late-Quaternary faulting was exposed in Trenches 2 and 3. Two colluvial units (S2 and S3) are faulted, east side down. The magnitude of displacement is difficult to measure because the S2 and S3 units do not occur west of the fault. The ages of units S2 and S3 are not known but are assumed to be less than 100,000 years (WCC, 1978). A younger colluvial unit, S1, doesn't seem to be offset. A down-to-the-east step at the base of S1 in T<sub>2</sub> may indicate faulting, but no shears were observed in S1, no scarp is present at the surface, the base of S1 is irregular, and a similar down-to-the-east step along the base of S1 was not observed in Trench 3. However, a small, east-facing scarplet (less than 0.5 foot high) occurs at Trench 3 and can be followed between Trenches 2 and 3. Holocene-active faulting may be suggested by this fault scarplet, but no clear association with fault features was observed in Trenches 2 and 3.

Geomorphic evidence of Holocene normal faulting along the Poorman Gulch fault was not observed by this writer during a brief field check in April 1983. The location of the three trenches excavated along the Poorman Gulch fault by WCC (1978) were observed during the field check. Trenches 2 and 3 are located about 10 feet apart, and the east-facing scarplet was not observed. It is conceivable that clean-up operations during back-filling of the trenches destroyed the scarplet in the immediate vicinity of the trenches, but this writer was unable to locate any evidence of a scarp northwest along the trend of the fault. Soil creep occurs at this location, and it is possible that the small scarplet was formed by soil creep and by coincidence occurred near the trace of the Poorman Gulch fault.

#### Rawhide Flat East Fault

The Rawhide Flat East fault, a N22°W-trending structure, offsets the Table Mountain Latite surface, forming a 55-foot high, east-facing scarp (WCC, 1978). The Rawhide Flat East fault coincides with a northwest-trending Mesozoic bedrock structure.

Four trenches across the Rawhide Flat East fault were excavated by WCC (1978) (figure 8). Trench 1 exposed a fault (N20°W trend, 74°E dip) that vertically offsets a remnant paleo-B soil horizon between 0.2 to 1.2 feet, down to the east. Shears extend up into an overlying colluvial unit estimated

to be about 35,000 years old (WCC, 1978). The uppermost colluvial unit is not offset, and there is no evidence of a scarp associated with this fault.

Trench 2, excavated just south of Trench 1, exposed an east-dipping fault with the same general attitude as the fault exposed in Trench 1. A paleo-B soil horizon is offset an undetermined amount, down to the east. Shears extend up into a colluvial unit (S3A) tentatively assigned an age of about 35,000 years B.P. (WCC, 1978). A younger colluvial (S2) unit of possible Holocene age may be disrupted by faulting. The youngest colluvial unit (S1) is clearly not displaced. However, an equally plausible explanation for the configuration of the base of the colluvial unit S2 would be post-faulting deposition, based on the occurrence of stones in-filling the fissure developed in colluvial unit S3A.

Trench 3, excavated about 250 feet north of Trench 2, exposed an east-dipping fault that offsets a paleosol about 1 foot, down to the east. Shears extend into overlying older colluvium, but Holocene colluvium is not offset.

Results of a very brief air photo interpretation (U.S.G.S. GS-BS, 1945) by this writer along the Rawhide Flat East fault are summarized on figure 8. The fault is well-defined where it offsets Table Mountain Latite, but is much less well-defined in Mesozoic bedrock. A brief field check by this writer in April 1983 failed to reveal geomorphic evidence of Holocene normal faulting along the Rawhide Flat East fault.

#### Rawhide Flat West Fault

The Rawhide Flat West fault is located about 1,500 feet west of, and generally is parallel to, the trend of the Rawhide Flat East fault (figure 8). The Rawhide Flat West fault displaces the Table Mountain Latite surface about 75 feet, down on the east (WCC, 1978). WCC (1978) excavated one trench (Trench 5) across the Rawhide Flat West fault (figure 8). A relatively continuous paleosol was preserved and did not seem to be offset. However, an earlier report by WCC (Alt, *et al.*, 1977) indicated that an eastward extension of Trench 5 revealed a faulted paleosol along a discrete fault plane. Evidence of Holocene faulting was not observed.

The Rawhide Flat West fault is well-defined within the Table Mountain Latite, but cannot be followed as a well-defined normal fault in Mesozoic bedrock (figure 8).

#### SEISMICITY AND CRUSTAL MONITORING

South of the Sacramento area, the seismicity is low along the Foothills fault zone. Although earthquakes have occurred along the Foothills fault zone in the FER study area, it is difficult to correlate this seismicity with specific geologic structures (J. Eaton, p.c., May 1983). However, it should be pointed out that until very recently seismicity was only lightly monitored in the foothills of the Sierra Nevada and pre-1975 events are poorly located and incompletely recorded.

First-order leveling surveys across segments of the Foothills fault system between Rocklin and Emigrant Gap indicate that vertical deformation has occurred since initial surveys were performed in 1947 (Bennett, 1978). This evidence of crustal strain is associated with recognized pre-Cenozoic faults within the two main branches of the Foothills fault system, the Bear Mountain and Melones fault zones. Approximately 20mm of down-to-the-west vertical deformation occurred along the Bear Mountain fault zone near Auburn between 1969 and 1977 (Bennett, 1978). This deformation occurred in a zone about 1-1/2 miles wide. Vertical deformation was also detected along the Melones

fault zone, but the sense of vertical displacement is not consistent. Crustal strain associated with the Foothills fault system typically occurs in a zone up to four miles wide, indicating that strain is distributed over a broad zone rather than along discrete, well-defined faults.

#### SLIP RATES

The slip rates for the Cleveland Hill fault were calculated to be about 1-1/2 feet per 100,000 years, or about 0.005 mm/yr. (Schwartz, et al., 1977). Other segments of the northern Foothills fault zone have comparably low slip rates (Bryant, 1983a, 1983b).

The Poorman Gulch fault, a segment of the southern Melones fault zone, offsets the base of the Mehrten Formation about 90 feet, down to the east. The age of the Mehrten Formation is about  $4.6 \times 10^6$  years, yielding a slip rate of about 0.006mm/yr. A local tuff member, the Chili Hill tuff, is offset about 200 to 250 feet across the Poorman Gulch fault. The age of the Chili Hill tuff is about  $2.3 \times 10^6$  years, indicating a slip rate of about 0.003mm/yr. The magnitude of the slip rate along the southern Melones fault zone is consistent with slip rates elsewhere along the Foothills fault zone.

#### 6. Conclusions

Woodward-Clyde Consultants (Alt, et al., 1977; Schwartz, et al., 1977), under contract to USBR and P.G. and E. (1978), conducted detailed studies of the Foothills fault system with respect to seismic safety for the proposed Auburn dam and Stanislaus nuclear plant site. Regional studies along the Foothills fault zone revealed evidence for late Cenozoic extensional faulting superimposed along prominent regional lineaments that define fault zones formed during the Mesozoic Era. A strong northwest-trending structural fabric in Mesozoic-age metamorphic rocks dominates landforms in the western Sierra Nevada foothills, but prominent, northwest-trending lineaments stand out.

Crustal monitoring of the western Sierran foothills indicates that down-to-the-west deformation along the Bear Mountain fault zone is occurring near Auburn (Bennett, 1978). Vertical deformation has occurred along the Melones fault zone near Gold Run, but the sense of displacement has not been consistent. It is possible that this strain, reflecting current east-west extension, is distributive at the surface and is taken up along several pre-existing Mesozoic-age shear zones. Thus, a discrete zone of deformation at depth may be manifested at the surface over a wide zone, perhaps several miles in width, with minor deformation occurring along several bedrock fault zones.

Geomorphic evidence of late Cenozoic normal faulting along the southern Foothills fault zone is generally expressed only within rocks of the Table Mountain Latite. Scarps, generally delineating down to the east displacement, are well-defined within the resistant volcanic rocks, but were not observed in relatively less resistant Mesozoic bedrock. This is no doubt a reflection of extremely low slip-rates (on the order of about 0.005mm/yr) along individual faults of the southern Foothills fault zone.

WCC concluded that seismic events in the Sierran foothills are associated with very small, geologically infrequent, incremental displacements having minor geomorphic surface expression which is rapidly obscured by erosive and soil forming processes in the metamorphic bedrock terrain (WCC, 1978).

Results of fault investigations along segments of the Bear Mountain and Melones fault zones conducted by WCC (Alt, et al., 1977; WCC, 1978) are summarized in Table 1.

## BEAR MOUNTAIN FAULT ZONE

Evidence of Quaternary faulting was observed along segments of the Rescue, Youngs Creek, Negro Jack Point, and Bowie Flat faults, based primarily on trench exposures (Alt, et al., 1977; WCC, 1978). Evidence of Holocene faulting along these segments of the Bear Mountain fault zone was not observed in trench exposures. Generally, these faults are not well-defined in detail, and geomorphic evidence of recent normal faulting was not observed.

## MELONES FAULT ZONE

Evidence of late Quaternary faulting was observed along segments of the Poorman Gulch, Rawhide Flat East, and Rawhide Flat West faults.

A small, east-facing scarp (less than 0.5 foot high) delineates a recently active trace of the Poorman Gulch fault (WCC, 1978) (figure 7). Trenches excavated across this scarp exposed evidence of an offset paleosol and faulted colluvium. The age of the faulted colluvium is not known, but a younger, overlying colluvial unit is not visibly offset. The east-facing scarp, which is not present in Trench 2, is not clearly associated with the principal fault exposed in Trench 3 (figure 7). A field check in April 1983 by this writer did not confirm the existence of this scarp between Trenches 2 and 3, and northwestward along the fault trend.

Evidence of late Quaternary offset was exposed in trenches excavated across the Rawhide Flat East fault (figure 8). Trenches 1, 2, and 3 exposed an east-dipping fault that offsets a remnant paleo-B soil horizon and an overlying colluvial unit. The colluvial unit, which is estimated to be about 35,000 years old (WCC, 1978), is overlain by a younger colluvial unit that is not visibly displaced by the fault. No geomorphic evidence of recent normal faulting was observed.

No evidence of Holocene faulting was observed in a trench excavated across the Rawhide Flat West fault (WCC, 1978). Geomorphic evidence of recent normal faulting was not observed along the Rawhide Flat West fault.

Holocene faulting along segments of the Bear Mountain and Melones fault zones in this FER study area cannot be ruled out, based on investigations by WCC (Alt, et al., 1977; WCC, 1978). However, the individual fault zones generally are not well-defined in detail, and rates of displacement along individual faults probably are not large enough to produce significant amounts of surface rupture. For example, a fault with a slip rate of 0.005mm/yr would produce only 5mm of offset in 1,000 years, 5cm in 10,000 years, or 50cm in 100,000 years. In addition, the general lack of Quaternary deposits along most of these fault zones severely limits the chances of meaningful active fault evaluation.

## 7. Recommendations

Recommendations for zoning faults for special studies are based on the criteria of sufficiently active and well-defined (Hart, 1980).

## BEAR MOUNTAIN FAULT ZONE

Do not zone traces of the Rescue, Youngs Creek, Negro Jack Point, and Bowie Flat faults. These faults are not well-defined and evidence of activity during Holocene time was not observed.

MELONES FAULT ZONE

Do not zone traces of the Poorman Gulch, Rawhide Flat East, and Rawhide Flat West faults. These faults are not well-defined and evidence of activity during Holocene time has not been demonstrated.

William A. Bryant

William A. Bryant  
Associate Geologist  
R.G. #3717

*I have reviewed  
and concur with the  
recommendations.  
EAB  
1/23/84*

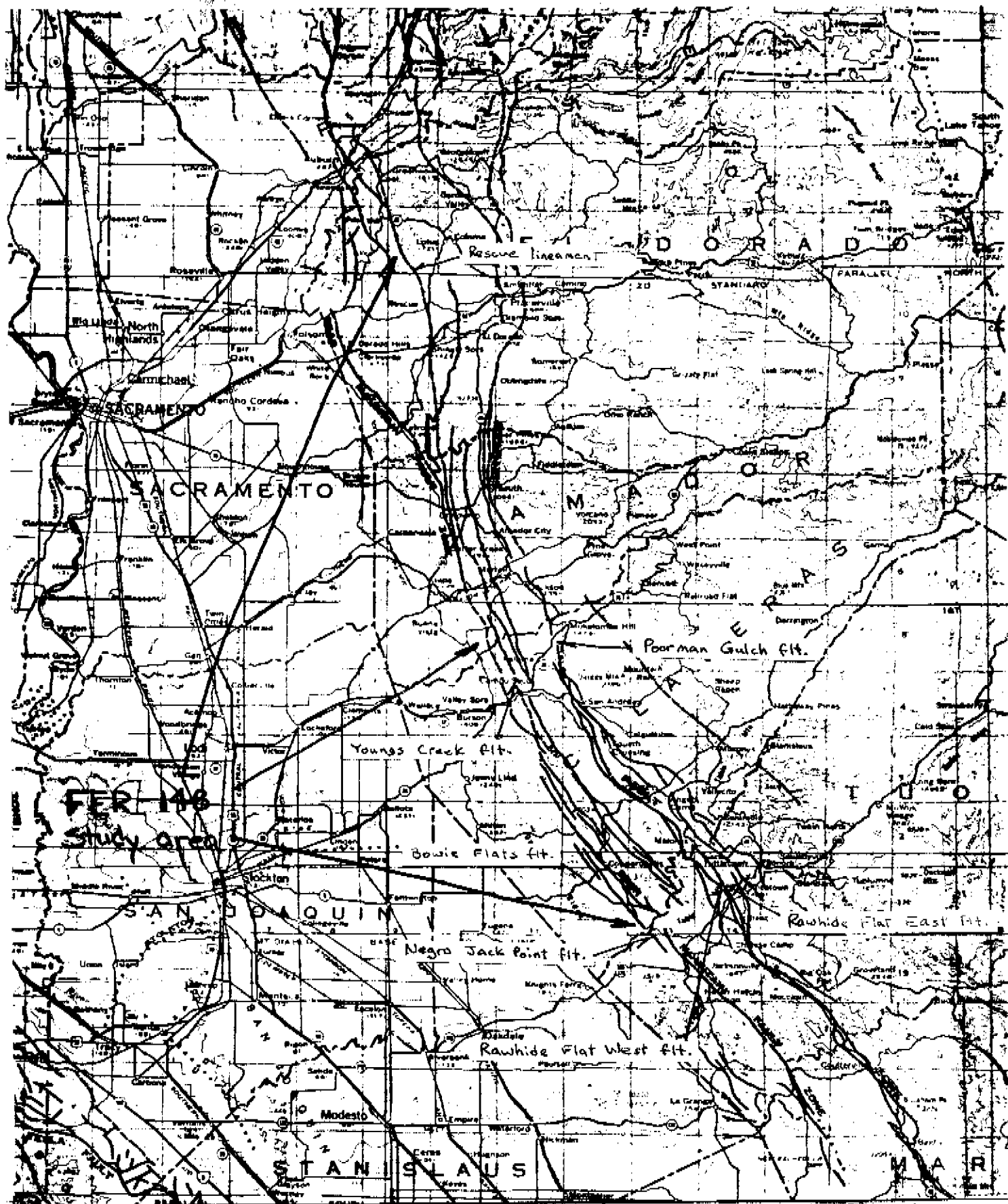


Figure 1 (to FER-148). Location of Bear Mountain and Melones fault zones, collectively the Foothills fault zone, evaluated in FER-148. Map from Jennings (1975), scale approximately 1:750,000.



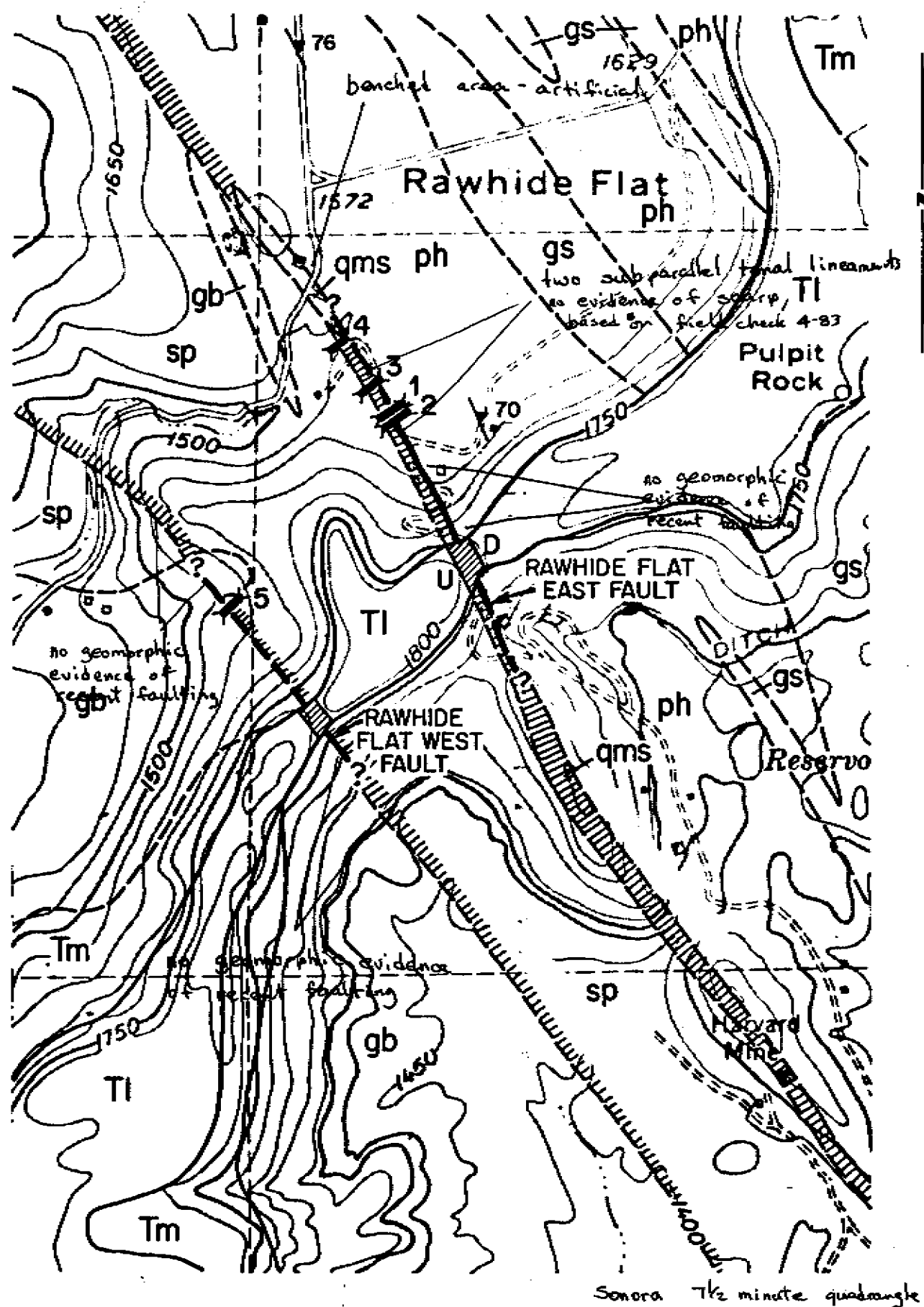
## SUMMARY OF TRENCHES

TRENCH NAME	LOCATION TOWNSHIP, RANGE SECTION	FORMATIONS ENCOUNTERED	LENGTH OF TRENCH (FT)	STRUCTURE INVESTIGATED	DISPLACED TERTIARY UNITS ENCOUNTERED	DISPLACED LATE QUATERNARY UNITS ENCOUNTERED	COMMENTS
<b>SOUTHERN STUDY AREA</b>							
<b>Table Mountain Area</b>							
Negro Jack Point 1	T1S, R13E, 8,9	Relief Peak(?) Formation	274	Negro Jack Point Fault	yes	uncertain	Paleo B horizon possibly displaced
Negro Jack Point 2	T1S, R13E, 8,9	Relief Peak(?) Formation Slate	160	Negro Jack Point Fault	no	no	Younger colluvium not displaced (< 20,000 years old)
Negro Jack Point 3	T1S, R13E, 6	Relief Peak(?) Formation	117	Negro Jack Point Fault	yes	yes	Fracture filling by older alluvium is sheared
Negro Jack Point 4	T1S, R13E, 6	Relief Peak(?) Formation	33	Negro Jack Point Fault	yes	uncertain	Fractures in older colluvium
Negro Jack Point 5 Series (3 trenches)	T1S, R13E, 6	Relief Peak(?) Formation	319	Negro Jack Point Fault	yes	none present	Deformation expressed as anticlinal folding
Negro Jack Point 6	T1S, R13E, 6	Table Mountain Latite	108	Negro Jack Point Fault	yes	yes	Paleo B horizon is present only in part of the trench; older alluvium and fracture fillings sheared
Bowie Flat 1	T1N, R13E, 5	Relief Peak(?) Formation	170	Bowie Flat Fault	yes	uncertain	Landslides obscure interpretation of Quaternary faulting
Bowie Flat 2	T1N, R13E, 5	Relief Peak(?) Formation	66	Bowie Flat Fault	yes	yes	Numerous small faults up to 15' east of main fault; Paleo B horizon displaced
Bowie Flat 3	T1N, R13E, 5	Serpentine, Relief Peak(?) Formation	40	Bowie Flat Fault	yes	no	Colluvium filled crack in bedrock; younger colluvium (< 20,000 years) not displaced
Bowie Flat 4 A and B (2 trenches)	T1N, R13E, 5	Serpentine, Relief Peak(?) Formation	A=113 B= 67	Bowie Flat Fault	yes	no	Soil relationships are complex near fault; younger colluvium (< 20,000 years) not displaced
Bowie Flat 5	T1N, R13E, 5	Serpentine, Relief Peak(?) Formation	28	Bowie Flat Fault	yes	no	Younger colluvium (< 20,000 years) not displaced; trench not on fault trace
Bowie Flat 6	T1N, R13E, 17	Serpentine, Greenstone	73	Bowie Flat Fault	none present	no	High groundwater level in trench precluded evaluation
Bowie Flat 7	T1N, R13E, 8	Serpentine, Greenstone	171	Bowie Flat Fault	none present	uncertain	Very well developed, undisturbed Paleo B horizon over fault, older colluvium may be displaced
Dear Mts. Fault 1	T1N, R13E, 28	Relief Peak(?) Formation	331	Bowie Flat Fault	yes	uncertain	Landslides obscure interpretation of Quaternary faulting
Dear Mts. Fault 2	T1N, R13E, 28	Relief Peak(?) Formation Serpentine	196	Bowie Flat Fault	yes	uncertain	Landslides obscure interpretation of Quaternary faulting
Shotgun Creek (Scrapedown)	T1N, R13E, 27	Table Mt. Latite, Serpentine	166	Bowie Flat Fault	yes	none present	Deformation predominantly expressed as folding
Green Spring Run 1	T1S, R13E, 24	Salt Springs Slate, Metavolcanics	288	Green Spring Run Structure	none present	uncertain	Table Mountain displacement on a projection of the Green Spring Run Structure; younger alluvium and colluvium (<20,000 years) not displaced
Keystone 1	T1S, R13E, 13	Slate, Greenstone	186	Keystone Structure	none present	no	Younger alluvium (< 20,000 years) not displaced; older colluvium (< 100,000 years) not displaced
Keystone 2	T1S, R13E, 13	Slate, Greenstone	352	Keystone Structure	none present	no	Younger alluvium (< 20,000 years) not displaced

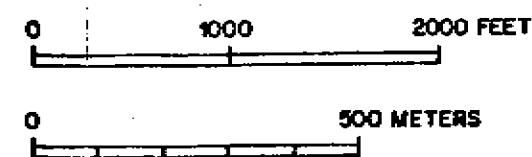
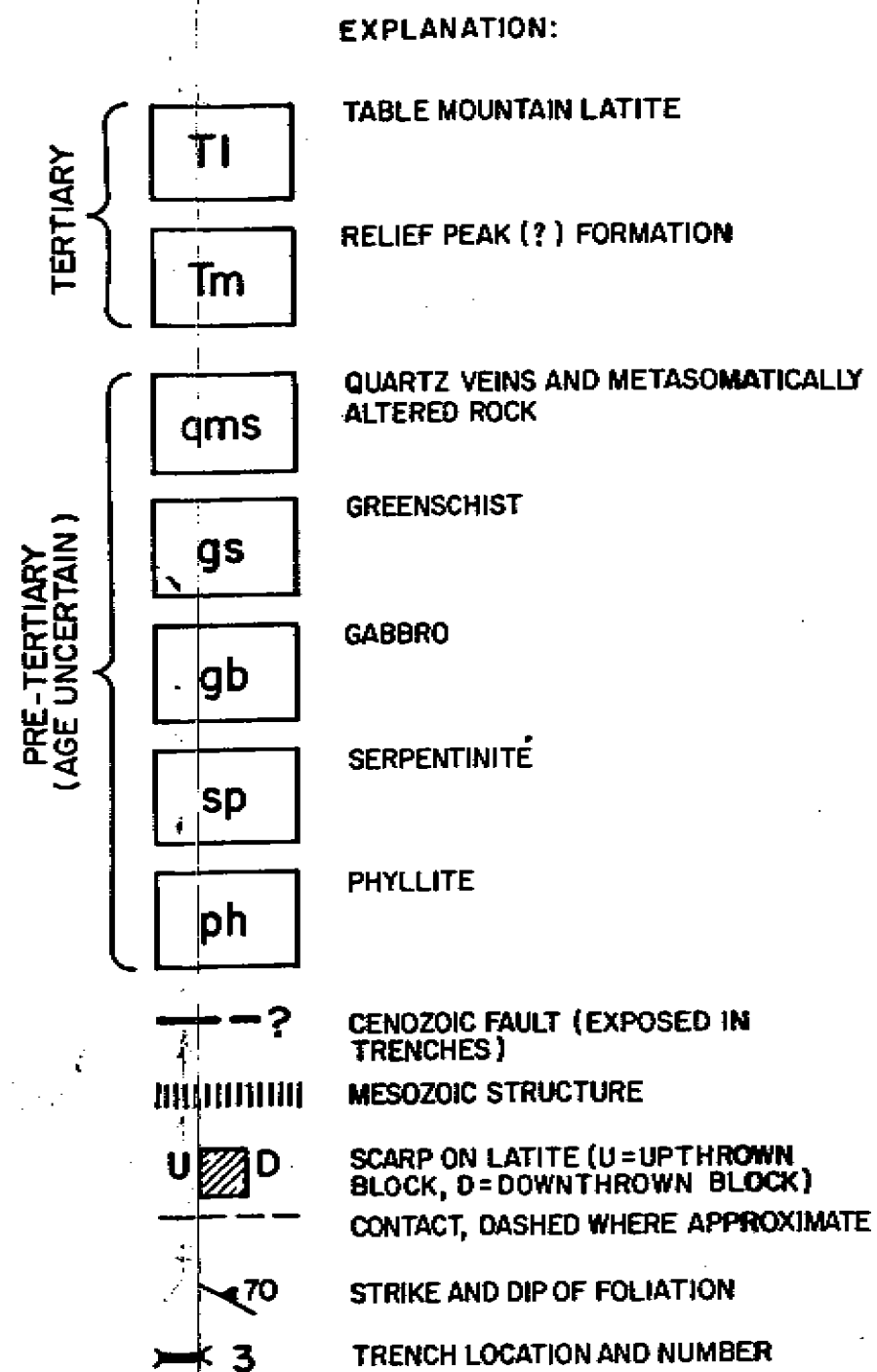
Table 1 (to FER-148). Summary of fault investigations along the southern Foothills fault zone by Woodward-Clyde Consultants (1978). Faults with evidence of Quaternary activity (blocked out in red) are evaluated in this FER. Refer to figure 3 for location of site investigations.

TRENCH NAME	LOCATION TOWNSHIP, RANGE SECTION	FORMATIONS ENCOUNTERED	LENGTH OF TRENCH (FT)	STRUCTURE INVESTIGATED	DISPLACED TERTIARY UNITS ENCOUNTERED	DISPLACED LATE QUATERNARY UNITS ENCOUNTERED	COMMENTS
Rawhide Flat 1	T1N, R14E, 9	Serpentine, Basic Intrusive Rocks	173	Rawhide Flat East Fault	none present	yes	Shearing and small displacements in Paleo B horizon; shearing in overlying colluvium
Rawhide Flat 2	T1N, R14E, 9	Serpentine, Basic Intrusive Rocks	26	Rawhide Flat East Fault	none present	yes	Shearing and small displacements in Paleo B horizon; shearing in overlying colluvium
Rawhide Flat 3	T1N, R14E, 9	Serpentine, Basic Intrusive Rocks	48	Rawhide Flat East Fault	none present	yes	Shearing and small displacements in Paleo B horizon; shearing in overlying colluvium
Rawhide Flat 4	T1N, R14E, 9	Serpentine, Basic Intrusive Rocks	76	Rawhide Flat East Fault	none present	no	Younger alluvium (< 20,000 years) not displaced
Rawhide Flat 5	T1N, R14E, 9	Serpentine, Basic Intrusive Rocks	138	Rawhide Flat West Fault	none present	uncertain	Paleo B horizon possibly displaced
<u>Don Pedro Area</u>							
Hetch Hetchy Junction 1	T2S, R14E, 6	Salt Springs Slate	135	Hetch Hetchy Junction Structure	none present	no	Paleo B horizon is present only in part of the trench; younger colluvium (< 20,000 years) not displaced
Hetch Hetchy Junction 2	T2S, R14E, 6	Salt Springs Slate	64	Hetch Hetchy Junction Structure	none present	no	Younger colluvium (< 20,000 years) not displaced
Vizard Creek 1	T3S, R14E, 28	Salt Springs Slate	108	Vizard Creek Fault	none present	no	Very well developed Paleo B horizon and older colluvium were not displaced
Twin Gulch 1	T3S, R14E, 15	Metavolcanic Rocks, Slate	196	Twin Gulch Fault	none present	no	
<u>Valley Springs-Mokelumne Hill Area</u>							
Mother Lode 1	T5N, R11E, 26	Mehrten Formation	78	Pooman Gulch Fault	yes	yes	Relationship obscured by landslide
Mother Lode 2	T5N, R11E, 26	Mehrten Formation, Dacite Dome Debris	60	Pooman Gulch Fault	yes	yes	Younger colluvium and weathering zones displaced
Mother Lode 3	T5N, R11E, 26	Mehrten Formation, Dacite Dome Debris	15	Pooman Gulch Fault	yes	yes	Younger colluvium and weathering zones displaced
Del Oro 1	T5N, R11E, 14	Calaveras Formation, Mokelumne Hill Quartz Diorite	57	Unnamed Strand of Melones Fault Zone (Strand and Koenig, 1965)	none present	no	No fault present at this locality
Youngs Creek 1	T4N, R11E, 8	Mehrten Formation, Serpentine	56	Youngs Creek Fault	yes	no	Total Cenozoic vertical displacement spread across a zone 6 to 10 feet wide with numerous small displacements; younger colluvium (< 20,000 years) not displaced; paleo B horizon possibly displaced
Youngs Creek 2	T4N, R11E, 8	Mehrten Formation	84	Youngs Creek Fault	yes	no	
Youngs Creek 3	T4N, R11E, 8	Mehrten Formation, Serpentine	140	Youngs Creek Fault	yes	no	
Evans Ranch 1	T4N, R11E, 5	Mehrten Formation, Serpentine	145	Eastern edge of Spring Valley Structure	no	no	
Haupt Creek 1	T4N, R11E, 10	Mehrten Formation, Logtown Ridge Formation	43	Haupt Creek Structure	no	no	
Haupt Creek 2	T4N, R11E, 10	Mehrten Formation, Melange	96	Haupt Creek Structure	no	no	
Haupt Creek 3	T4N, R11E, 10	Mehrten Formation, Melange	110	Haupt Creek Structure	no	no	
Haupt Creek 4	T4N, R11E, 10	Terrace Material, Melange	72	Haupt Creek Structure	no	no	

Table 1 (to MER-148). p. 2.  
(continued)



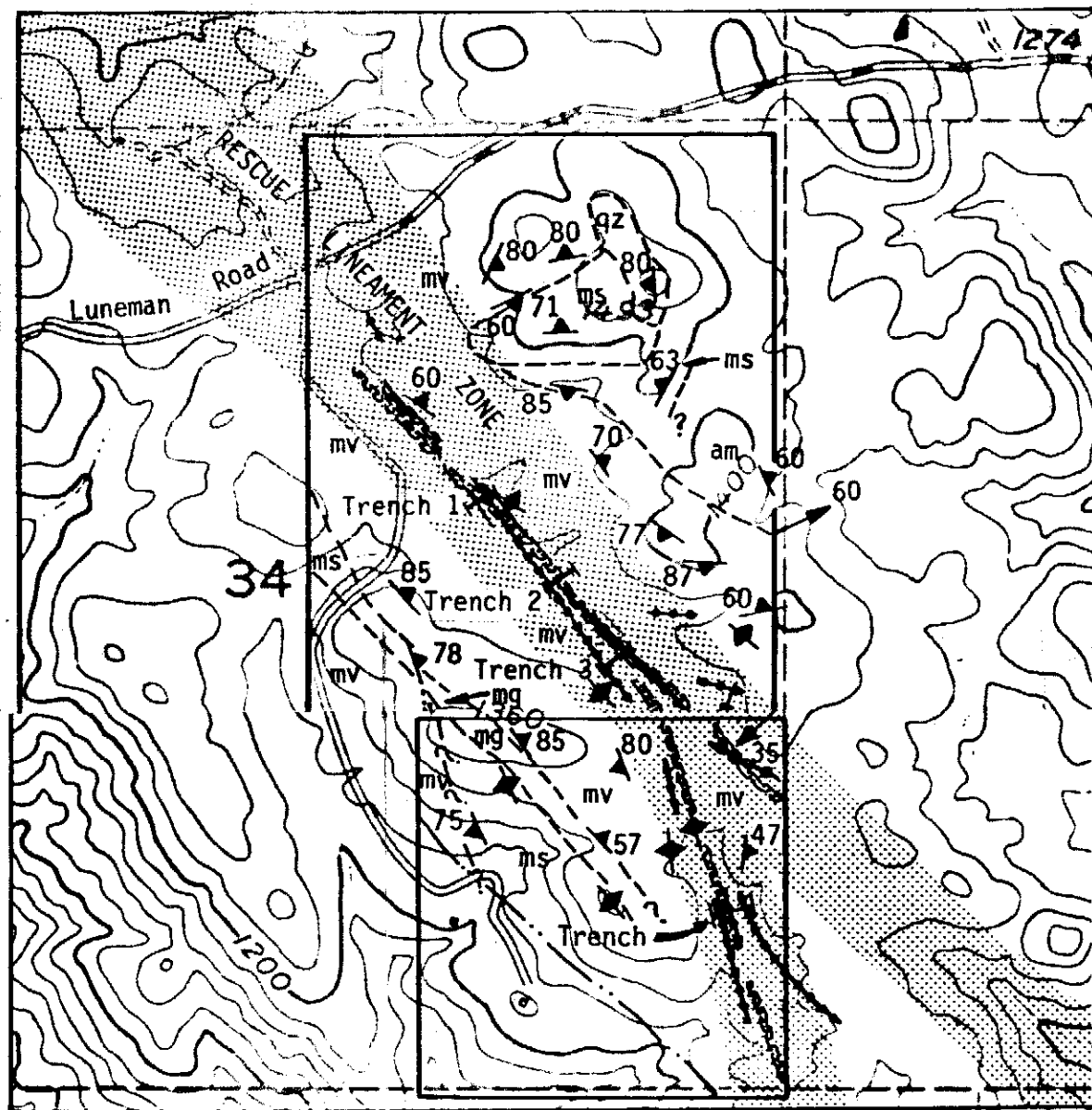
NOTES:  
MODIFIED AFTER ERIC AND OTHERS (1955).  
FOR LOCATION SEE FIGURE C.4-4.



## STANISLAUS NUCLEAR PROJECT

RAWHIDE FLAT GEOLOGY  
AND TRENCH LOCATIONS

Figure 8 (to FER-148). Rawhide Flat East and Rawhide Flat West faults, showing location of trenches excavated by Woodward-Clyde Consultants (1978). Annotations are by Bryant (this report), based on brief air photo interpretation.



Coloma 7½ minute quadrangle, T11N, R9E

# EXPLANATION

PRE-CENOZOIC	mv	Metavolcanic rock, undifferentiated	—●—●—●—	Linear element
	ms	Metasedimentary rock, undifferentiated	▨	Lineament zone
	am	Amphibolite	— —	Trench location
	qz	Quartzite	↗↘↗↘	Shear zone with serpentinite
	mg	Metagabbro		

- 70 ↗ Strike and dip of foliation
- ↗ Strike of vertical foliation
- 20 ↗ Trend and plunge of lineation
- ? Lithologic contact; dashed where approximately located, queried where uncertain

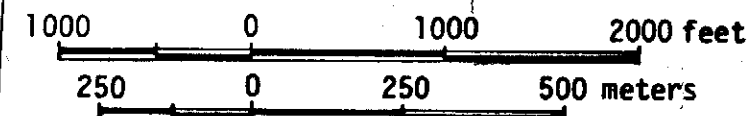


Figure 4 (to FER-148). Segment of the Rescue lineament, showing the location of the Luneman Road and Knolls exploration sites of Woodward-Clyde Consultants (Schwartz, et al., 1977).

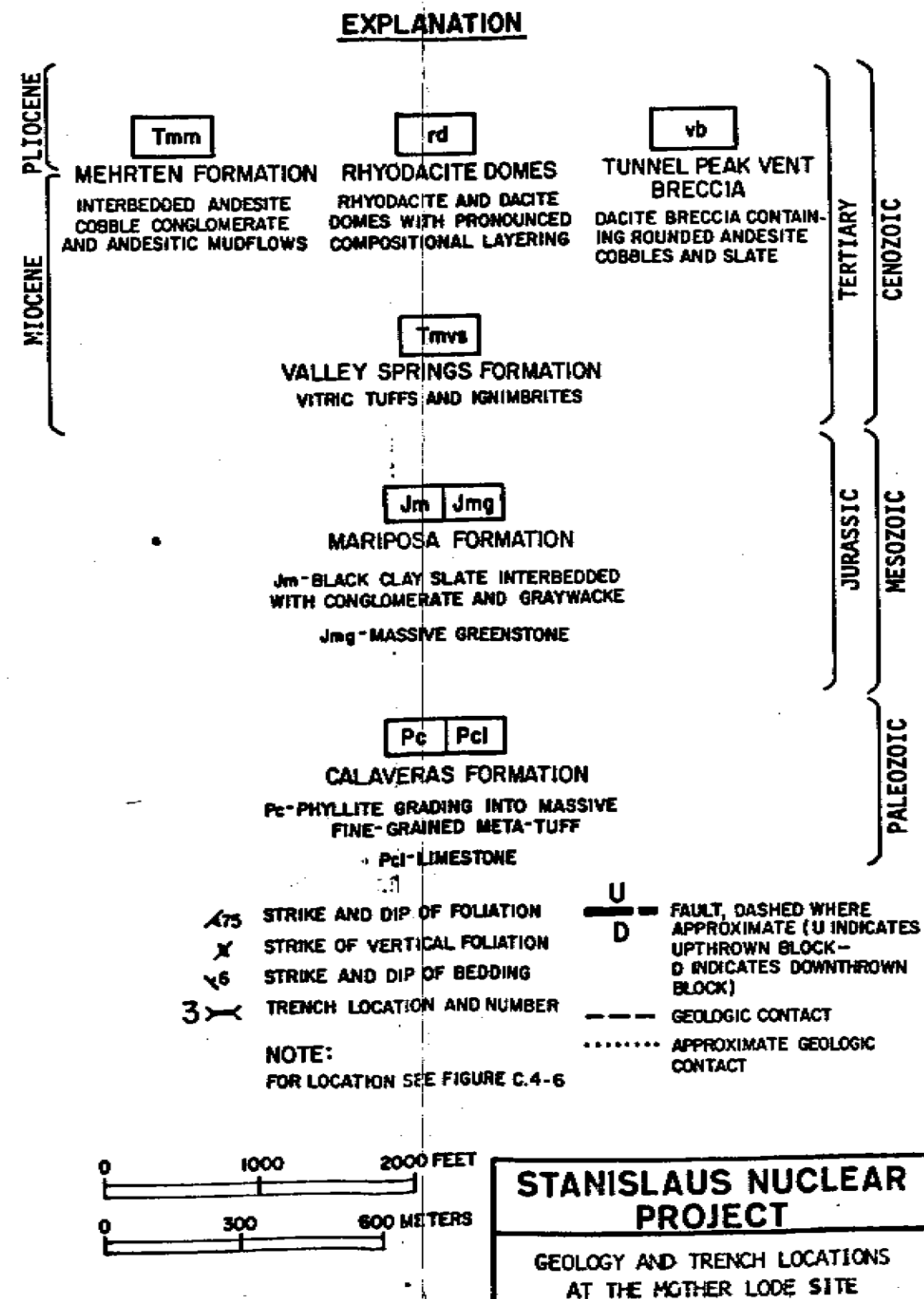
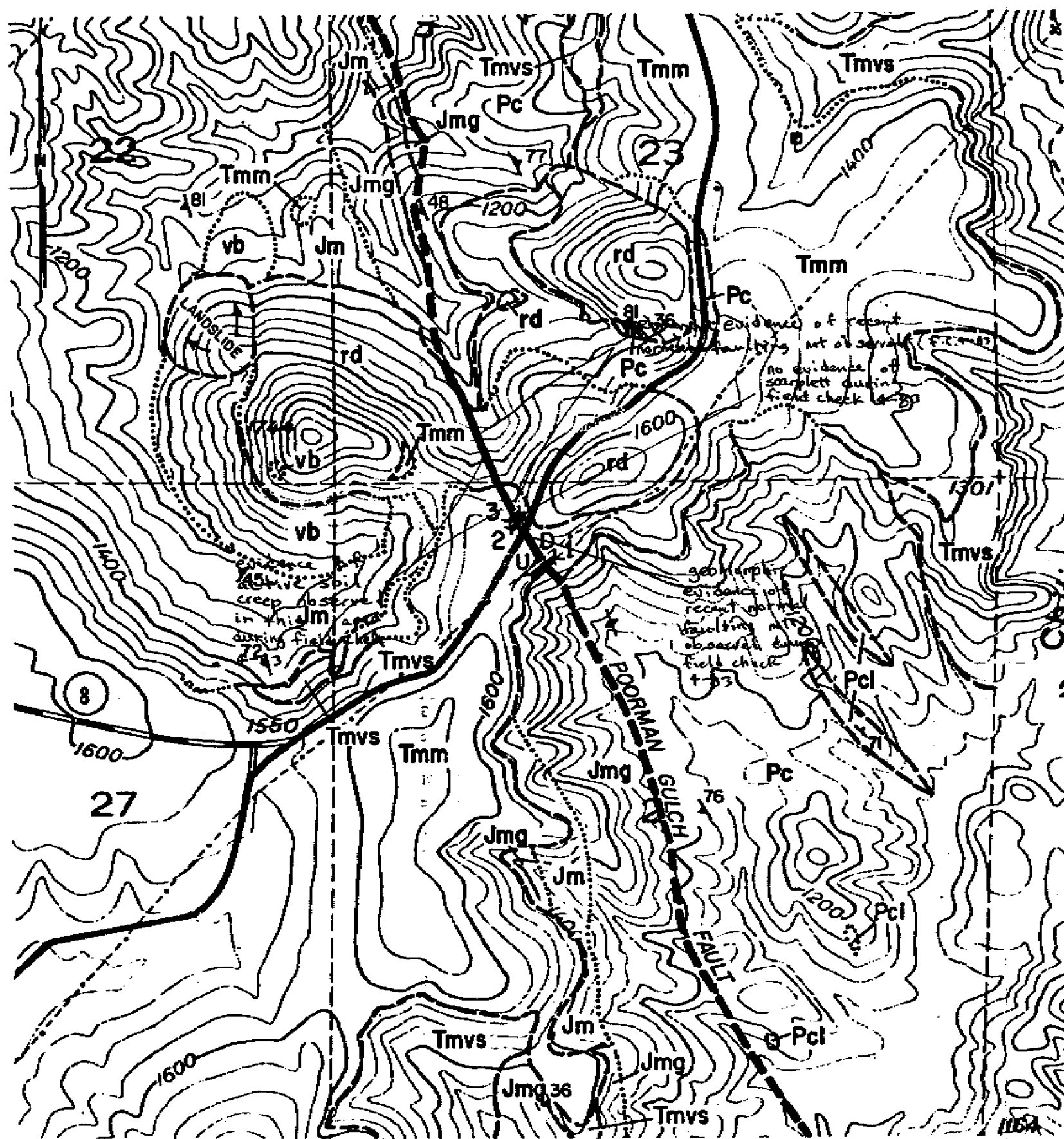
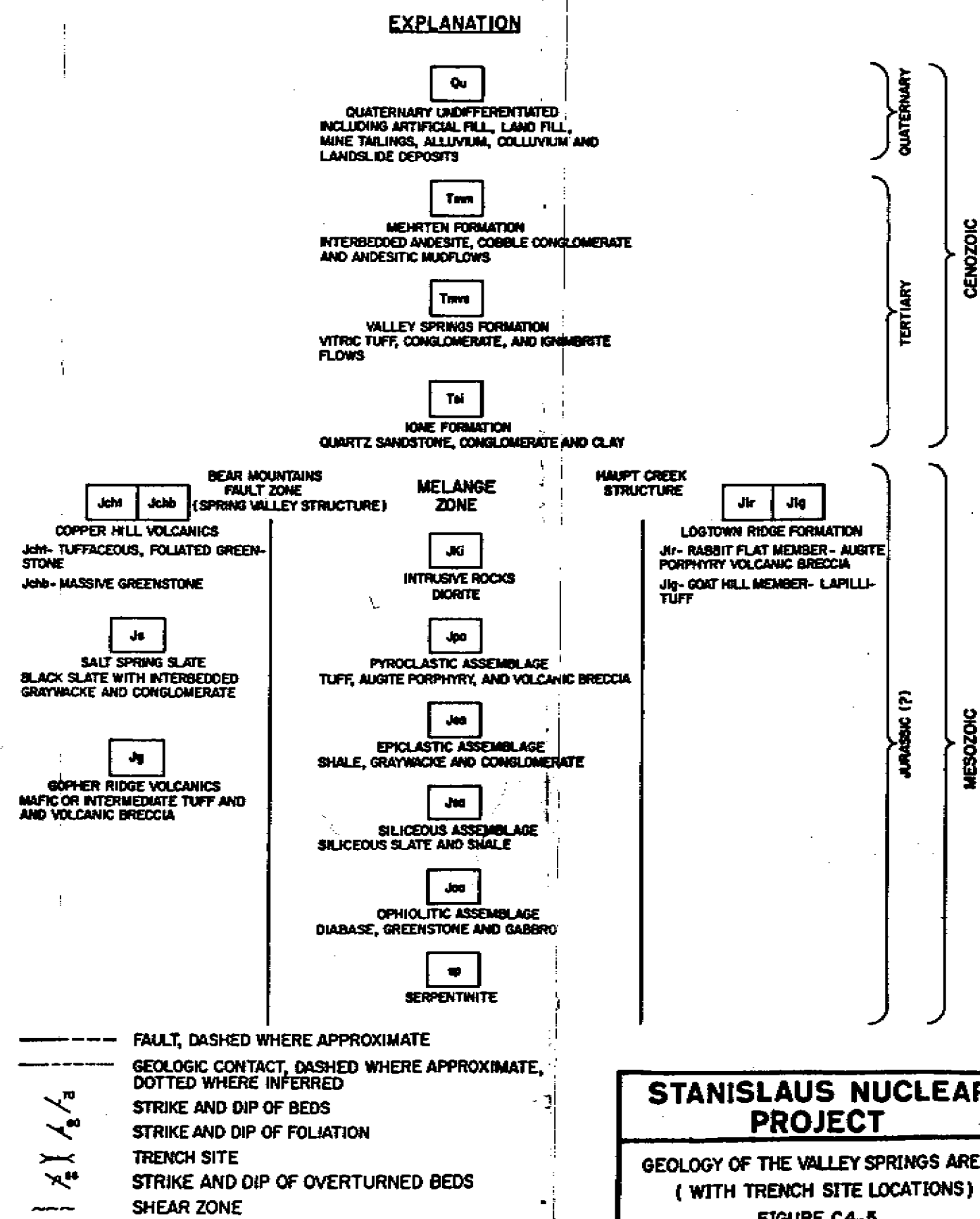


Figure 7 (to FER-148). Poorman Gulch fault, showing location of trenches excavated by Woodward-Clyde Consultants (1978).



SOURCES:  
PARKISON (1976), AND FIELD WORK BY WOODWARD-CLYDE CONSULTANTS 1976-1977.

NOTE:  
LOCATION OF MAP AREA SHOWN ON FIGURE C.4-2.



**STANISLAUS NUCLEAR PROJECT**  
GEOLOGY OF THE VALLEY SPRINGS AREA ( WITH TRENCH SITE LOCATIONS )  
FIGURE C4-5

Figure 5 (to FER-148). Youngs Creek fault, showing the general location of trenches excavated by Woodward-Clyde Consultants (1978).

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